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We designed a study to evaluate the efficacy of cyanoacrylate adhesive (CA) in the temporary closure of scleral lacerations. Ocular injuries are expected to comprise up to 10% of total casualties on the modern battlefield and would overwhelm the limited medical facilities near front lines. An expedient method of stabilizing open eyes is needed. A 6 mm laceration was created 3 mm posterior to the limbus in albino rabbits. The animals were randomized into three groups: standard closure with sutures (13), closure with CA (28), or untreated (21). The animals were euthanized at 2 days, 1, 2, 4, and 8 weeks. On histopathologic examination, a fibrous bridge was noted in all animals by 2 weeks. Prior to fibrous bridge formation, intraocular pressures (IOP's) and dark-adapted electroretinogram (ERG) a- and b-wave amplitudes were lower in open eyes compared to those in which wounds were surgically closed using CA or suture. Flare was increased in open eyes. The clinical course of the CA group compared favorably with eyes closed by the standard suture technique. This study supports the efficacy of using cyanoacrylate adhesive as a temporary, expedient method of closing scleral lacerations.

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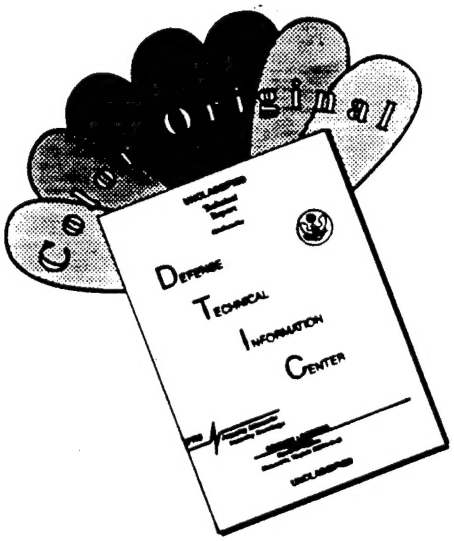

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ABSTRACT

We designed a study to evaluate the efficacy of cyanoacrylate adhesive (CA) in the temporary closure of scleral lacerations. Ocular injuries are expected to comprise up to 10% of total casualties on the modern battlefield and would overwhelm the limited medical facilities near front lines. An expedient method of stabilizing open eyes is needed. A 6 mm laceration was created 3 mm posterior to the limbus in albino rabbits. The animals were randomized into three groups: standard closure with sutures (13), closure with CA (28), or untreated (21). The animals were evaluated by clinical exam, intraocular pressure (IOP), and bright-flash electroretinogram (ERG) prior to both wound placement and enucleation. The animals were euthanized at 2 days, 1, 2, 4, and 8 weeks. On histopathologic examination, a fibrous bridge was noted in all animals by 2 weeks. Prior to fibrous bridge formation, IOP's and dark-adapted ERG a- and b-wave amplitudes were lower in open eyes compared to those in which wounds were surgically closed using CA or suture. Anterior chamber flare was increased in open eyes. The clinical course of the CA group compared favorably with eyes closed by the standard suture technique. This study supports the efficacy of using cyanoacrylate adhesive as a temporary, expedient method of closing scleral lacerations.

BACKGROUND

Ocular injuries are of increasing significance in war. The incidence of eye injuries sustained by American forces has increased with the deployment of modern munitions, reaching 9% of total casualties in Vietnam (1). In Combat Support Hospitals, ophthalmologists have limited time and resources for the closure of scleral lacerations. Inadequate closure places the soldier at risk for expulsion of eye contents and/or infection during evacuation to fully equipped medical facilities (2). An expedient method of

stabilizing eyes is needed. Cyanoacrylate adhesives have been studied extensively in Ophthalmology (3-6). Their success in the closure of corneal wounds suggested potential for the closure of scleral lacerations. If the application of tissue adhesives could be done in a rapid and effective manner, using only loupes for magnification, the management of these frequent combat wounds would be vastly improved.

MATERIALS AND METHODS

New Zealand White rabbits of either sex, weighing between 2.5 and 3.5 kg, were anesthetized using intramuscular injection of a ketamine and xylazine combination (25 mg/kg and 2.5 mg/kg). The right eye was dilated using 1% cylclopentolate and 10% phenylephrine. An eye examination to include slit lamp examination, IOP measurement, dilated fundus examination, and dark- and light-adapted bright-flash ERG was performed. The eye was prepped and draped in a sterile fashion. A peribulbar block using 2% xylocaine was given after which a 90 degree limbal peritomy was performed. A 6 mm scleral incision was created parallel and 3 mm posterior to the limbus with a #51 Beaver blade (R. Beaver Inc., Waltham, MA). Prolapsed vitreous was excised using cellulose sponges and scissors. The animals were randomized into three groups: the wound was either left open, closed using interrupted 7-0 Vicryl sutures, or closed using n-butyl cyanoacrylate adhesive (Histoacryl blau, B. Braun Melsungen AG, Melsungen, Germany). Cyanoacrylate was applied using a tuberculin syringe and a 26 gauge needle following careful apposition and drying of wound edges. The conjunctiva was closed with interrupted 6-0 plain gut sutures. Gentamicin, 20 mg (1/2 cc), was injected subconjunctivally, 180°from the wound, at the end of each case. Prior to enucleation, each rabbit was anesthetized with the ketamine and xylazine combination and the ocular examination repeated. The rabbit was then euthanized with intracardiac injection of 0.25 ml/kg of Euthanasia-6 (Veterinary Laboratory, Inc., Lenexa, KS). The eye

was enucleated, fixed in 10% formalin, grossed, paraffin embedded, serially sectioned, and stained with hematoxylin-eosin, Masson's trichrome, or alcian blue. Data were analyzed using Kruska-Wallis oneway nonparametric analysis of variance. For the wound integrity experiments, the rabbits were anesthetized as stated above including the peribulbar block. A 20 gauge cannula was inserted into the vitreous cavity and connected to both a pressure transducer and a liter bag of sterile saline. IOP was elevated by inflating a sphygmomanometer around the bag of saline or by digital message of the globe. The IOP measured by the transducer was confirmed using a Schiotz tonometer. Wound integrity was monitored by Seidel testing (disappearance or dilution of fluorescein overlying the wound). This protocol was executed in accordance with the animal use guidelines set forth by The Association for Research in Vision and Ophthalmology.

RESULTS

Figures 1 - 3 demonstrate the technique used to close the full thickness scleral lacerations with cyanoacrylate adhesive. The equipment needed was minimal and consisted of commonly used ophthalmic instruments (Fig. 4). Histopathologic examination revealed the formation of a fibrous bridge between the wound edges in all animals by two weeks, regardless of treatment. Figure 5 is an example of an open eye (neither glued nor sutured) prior to a collagenous fibrous bridge formation. Note the absence of collagen within the wound (collagen stains blue, as in sclera). Figure 6 is an example of a wound in an eye seven days after closure with cyanoacrylate adhesive. Note blue staining collagen within the wound.

Prior to fibrous bridge formation, intraocular pressures and dark-adapted ERG a- and b-wave amplitudes were lower in open eyes compared to those in which wounds were closed surgically using cyanoacrylate or suture (Table). Note the profound hypotony in the OPEN eyes. Anterior chamber flare was comparatively increased in

the OPEN group. There was not a statistically significant difference in the amount of anterior chamber cellular reaction among the groups (Table).

Figures 7 and 8 are representative intraocular pressure tracings. Figure 7 demonstrates a gradual increase in IOP from a baseline of 19 mm Hg to a maximum of 200 mm Hg over 5 minutes. Not shown is the maintenance of IOP at 200 mm Hg for up to 5 minutes without evidence of wound leak as determined by a drop in IOP and/or positive Seidel test. Figure 8 is a continuation of the same tracing during which IOP was rapidly increased and decreased by digital message (following sustained IOP increase). During the phase of rapidly changing IOP there was no evidence of wound leak.

DISCUSSION

Histopathologic analysis of the wounds revealed that all animals formed a fibrous bridge closing the scleral lacerations by two weeks. Prior to this, eyes closed with either sutures or cyanoacrylate adhesive maintained more normal intraocular pressure and ERG values. Significantly more anterior chamber flare was noted in the open eyes, most likely reflecting their profound hypotony. There was no statistically significant difference in the amount of intraocular inflammation as measured by anterior chamber cellular reaction among the three groups. The clinical course of glued eyes compared favorably with the sutured group. No significant differences in any of the measured parameters were noted among the three groups following formation of the fibrous bridge. Eyes that were closed with cyanoacrylate adhesive were shown to withstand both sustained elevation of intraocular pressure and vigorous ocular massage without wound leakage as determined by Seidel testing.

CONCLUSIONS

A large number of ocular injuries will occur in any future armed conflict. Ophthalmologists near the battlefield will have limited time and resources to manage lacerated eyes. Definitive management of severely injured eyes will occur in medical centers remote from the battlefield. This study demonstrates the efficacy of cyanoacrylate adhesive in the temporary closure of scleral lacerations. The application of cyanoacrylate adhesive requires minimal time and equipment. Eyes closed with cyanoacrylate adhesive will withstand the increases in intraocular pressure expected to occur during air evacuation or inadvertent mechanical manipulation of the globe.

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FIGURE 1: Full-thickness scleral laceration prior to closure.

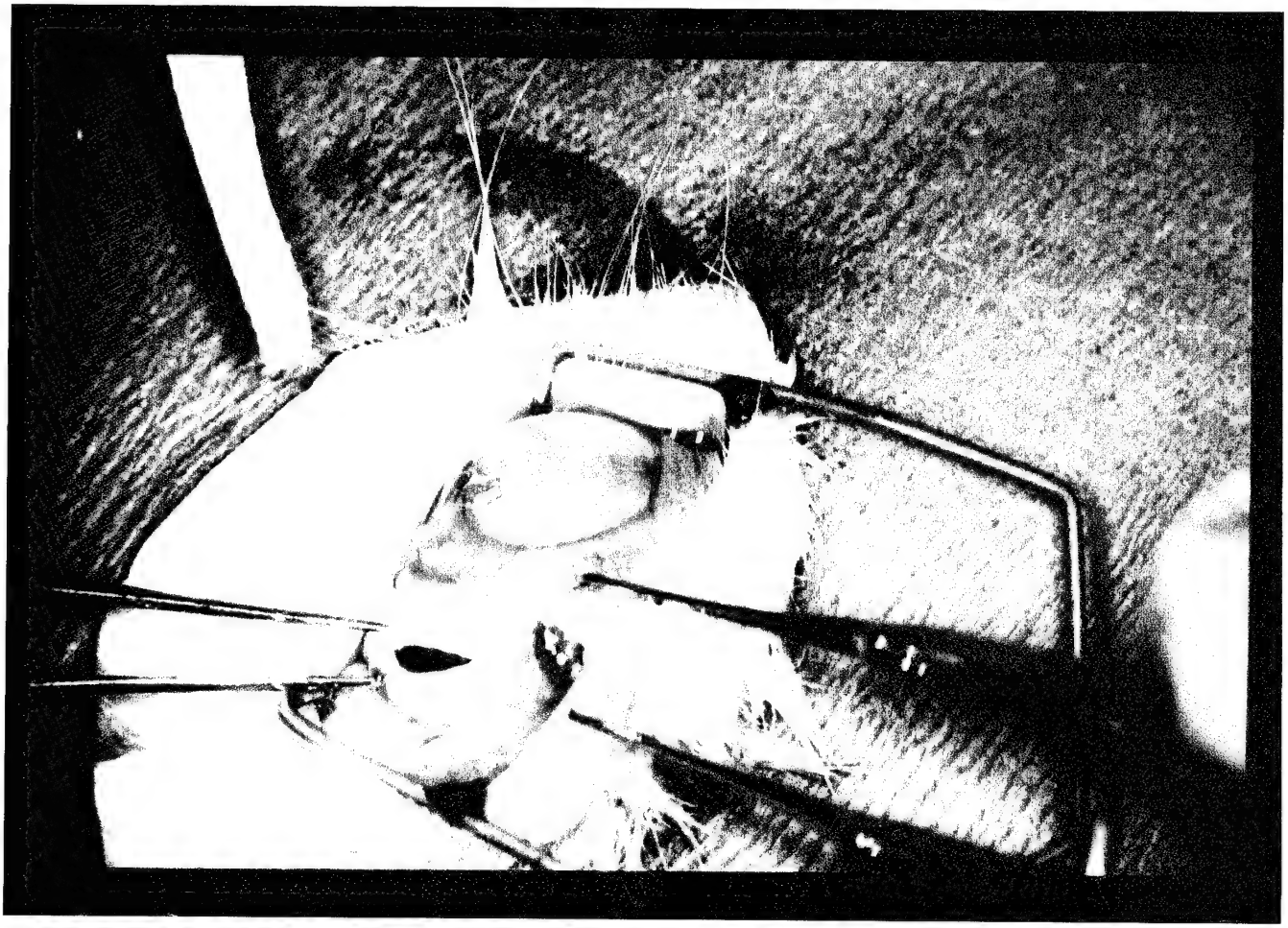


FIGURE 2: Wound is closed with forceps following excision of prolapsed vitreous. The edges must be carefully apposed and dried prior to application of cyanoacrylate adhesive.

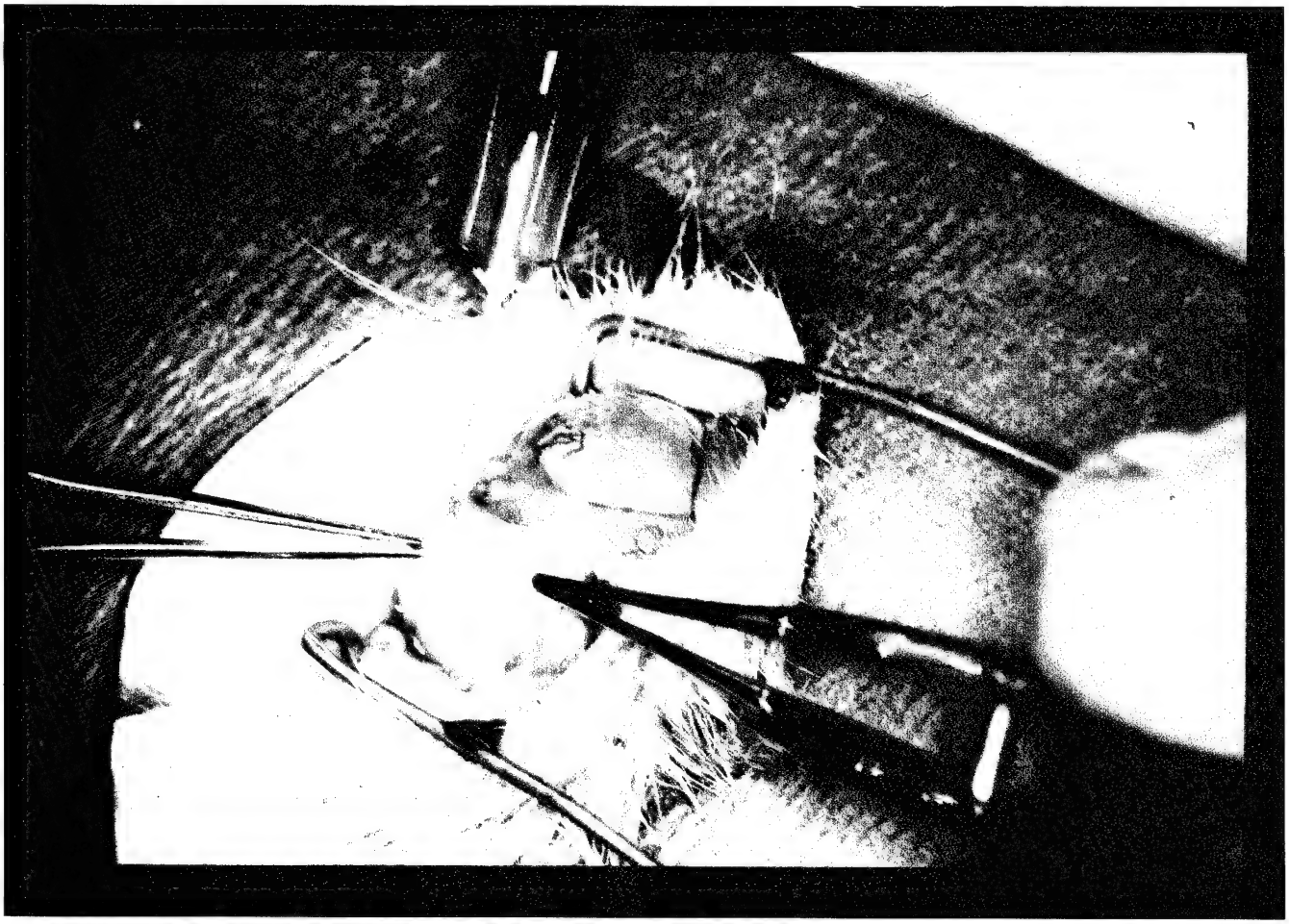


FIGURE 3: Securely closed wound after application of cyanoacrylate.

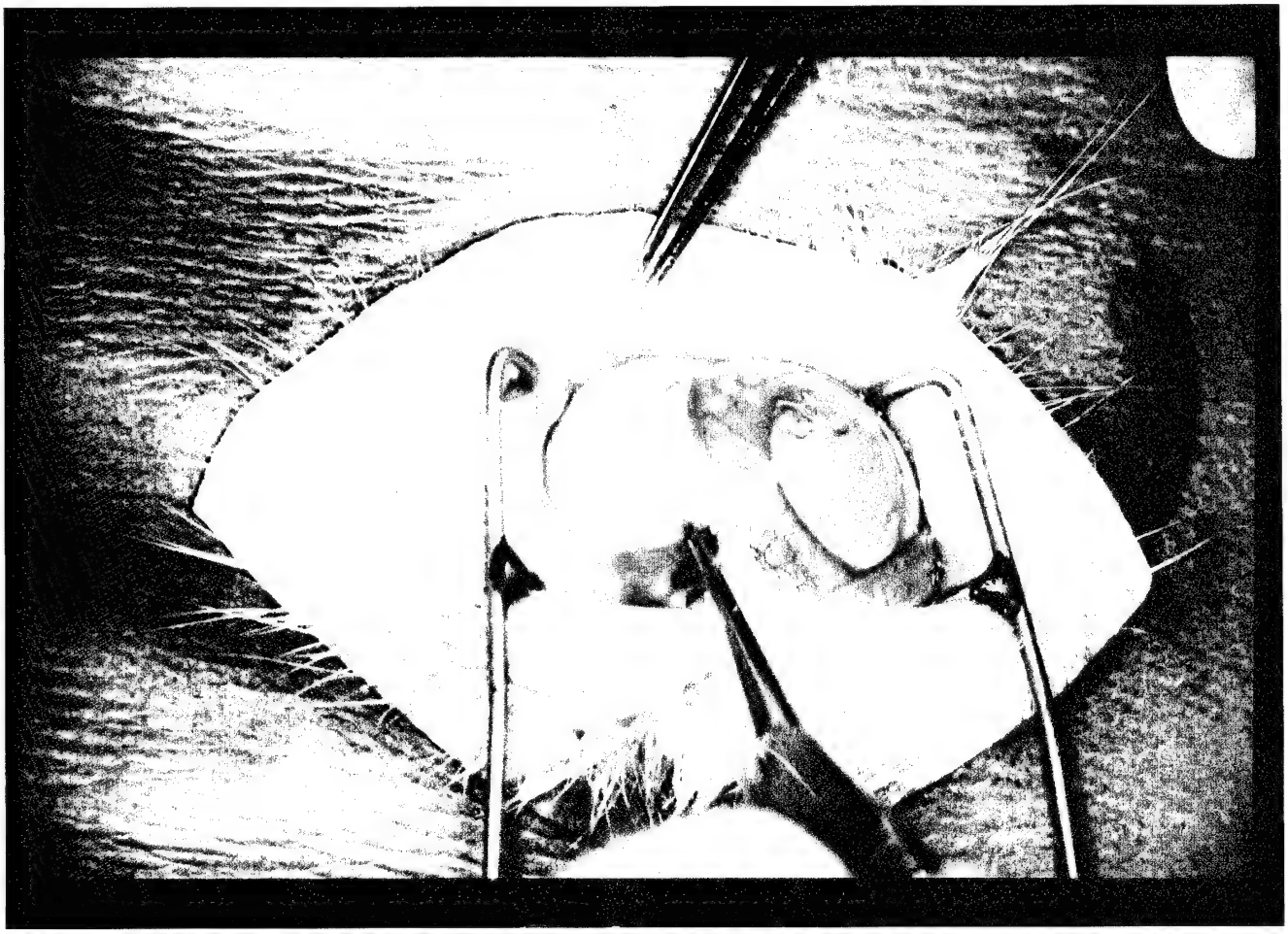


FIGURE 4: Equipment used to close scleral lacerations with cyanoacrylate adhesive.

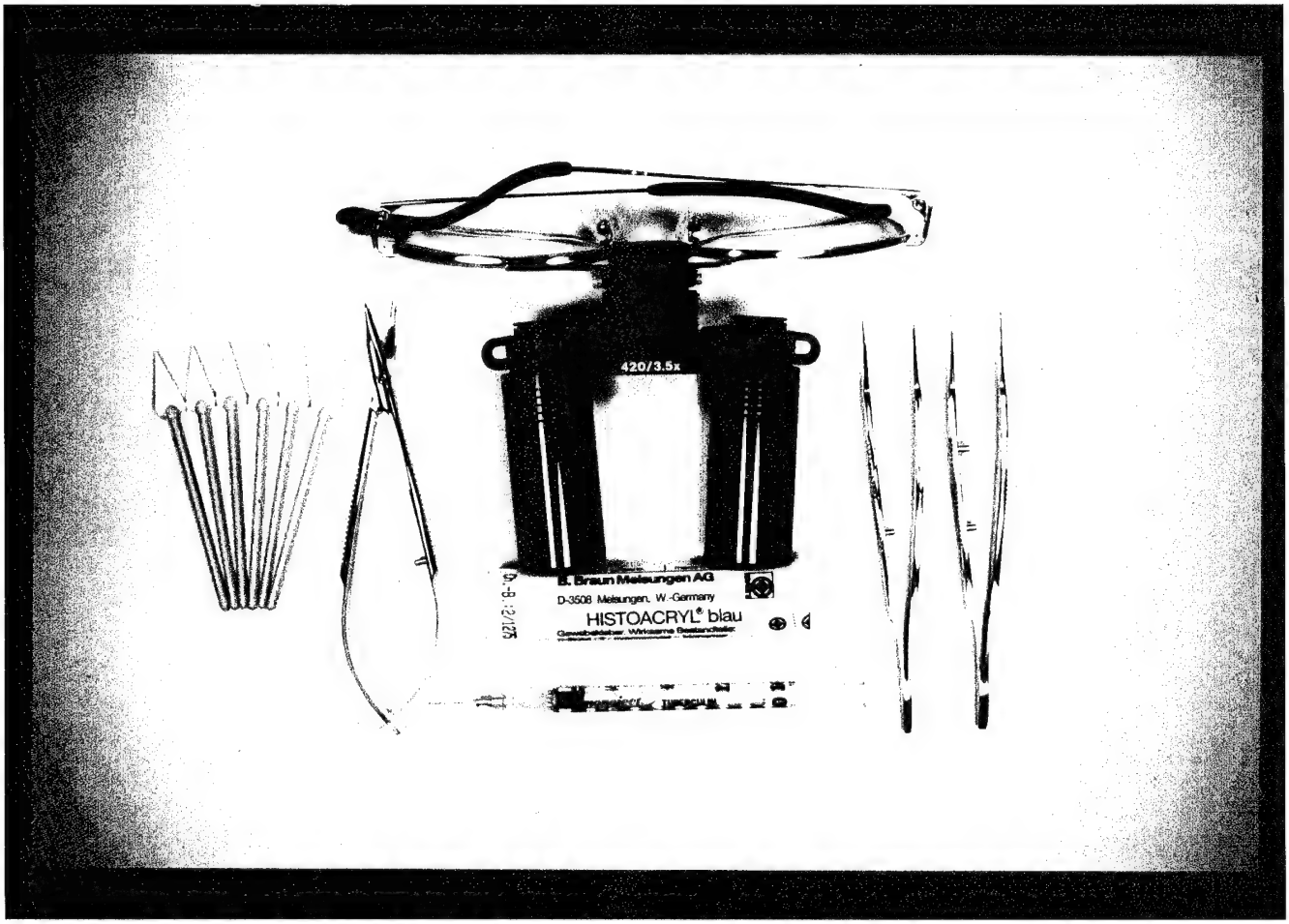
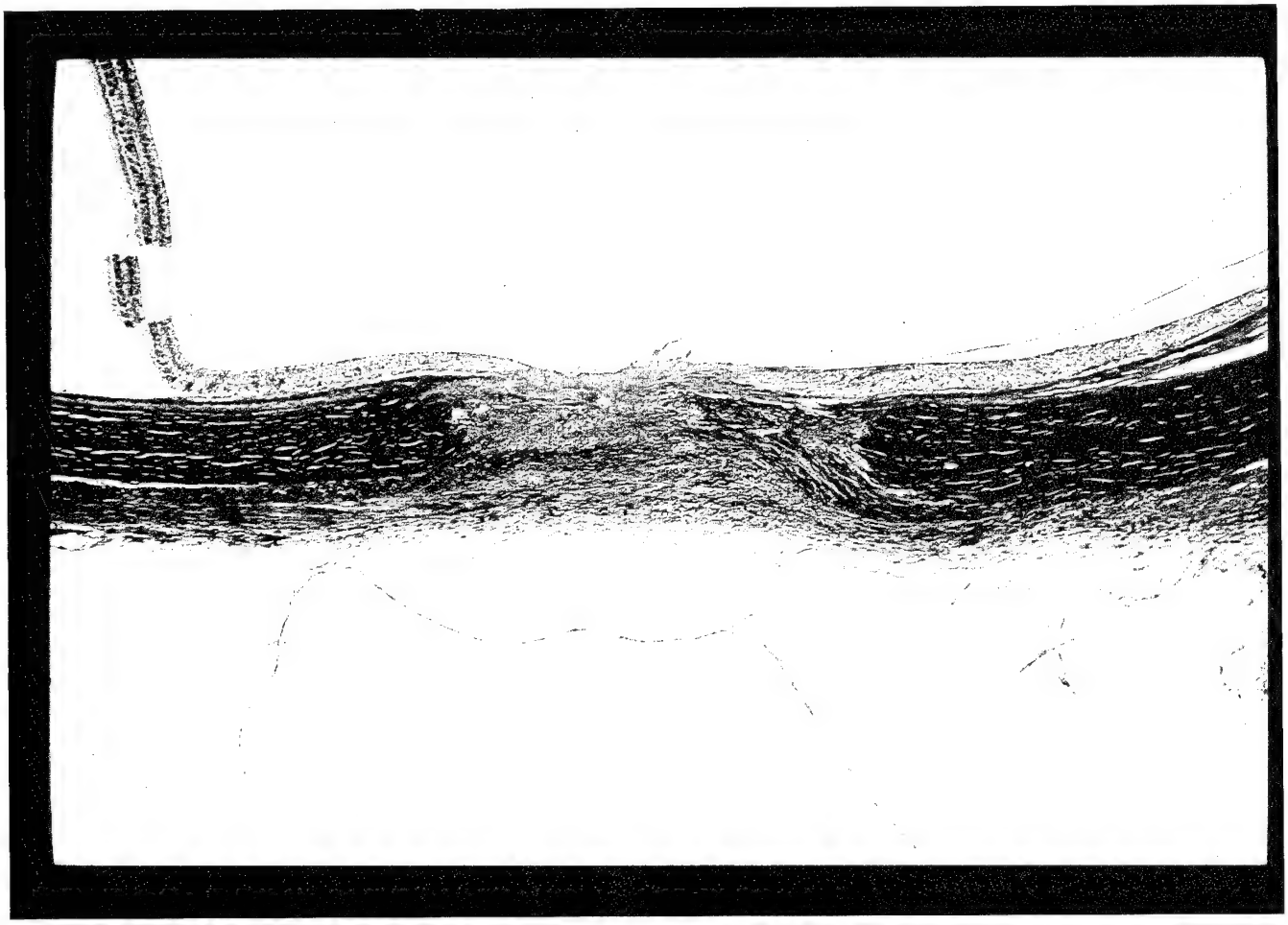


FIGURE 5: Histopathological section of OPEN eye (neither glued nor sutured) prior to fibrous bridge formations (Masson's trichrome stain; original magnification 10 x).

FIGURE 6: Histopathologic section of an eye seven days after closure using cyanoacrylate adhesive (Masson's trichrome stain; original magnification 10 x).



	OPEN (n=5)	CA (n=15)	SUTURE (n=6)	
IOP (mm Hg)	0.0± 0.0	9.0± 2.1	13.0± 3.2	P=0.0246
a-wave (mV)	40.7±11.9	68.8± 6.8	89.9± 8.0	P=0.0304
b-wave (mV)	83.0±22.6	176.2±16.3	193.4±13.0	P=0.0111
Flare (0-4+)	2.8± 0.2	0.9± 0.3	0.3± 0.2	P=0.0029
Cell (0-4+)	2.2± 0.9	0.5± 0.3	0.8± 0.5	P=0.1396

Mean ± SEM

FIGURE 7: Intraocular pressure tracing ranging from a baseline of 19 mm Hg to a maximum of 200 mm Hg. Stepwise increases represent successive pumps of the sphygmomanometer around the bag of saline.

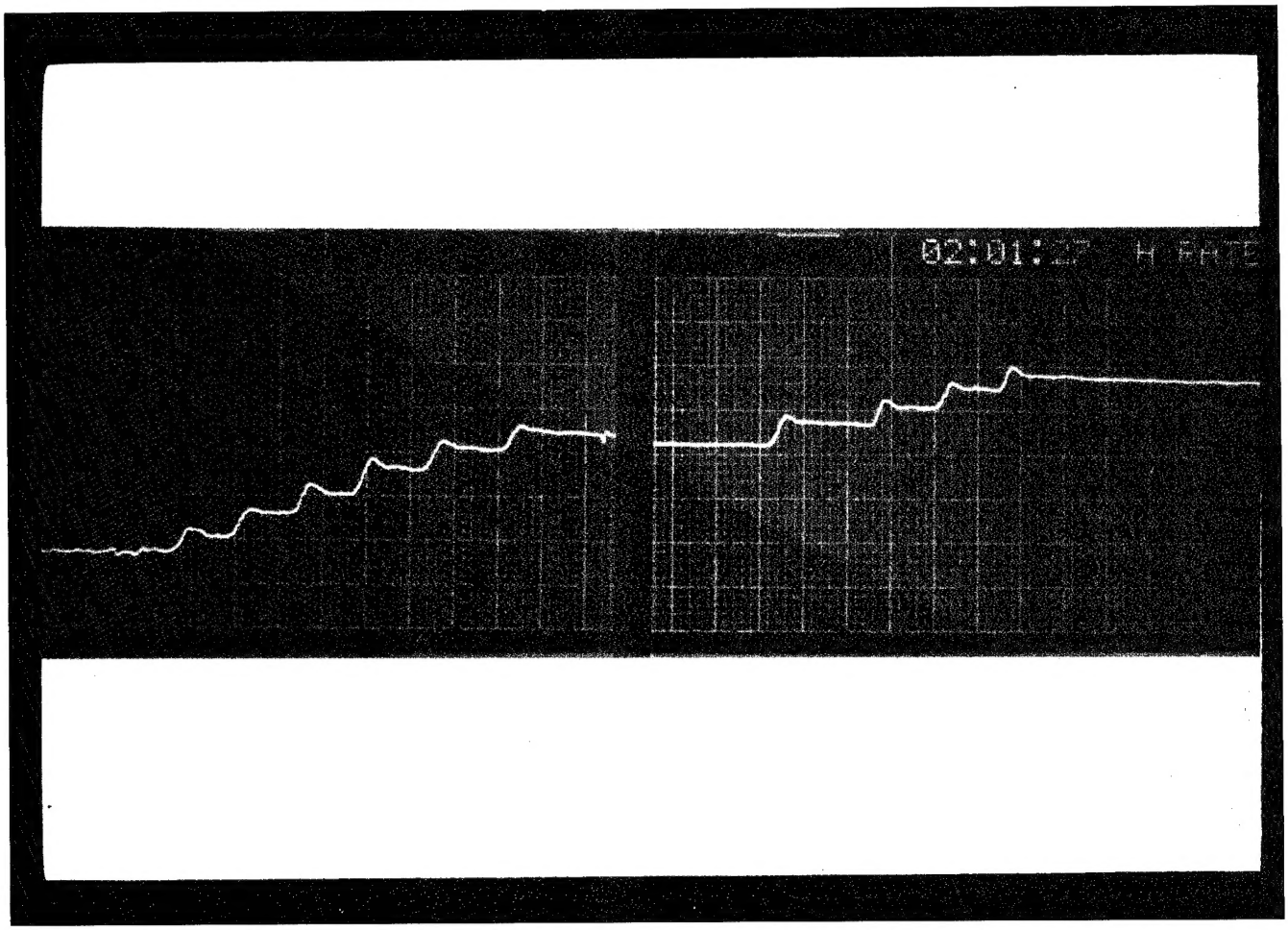
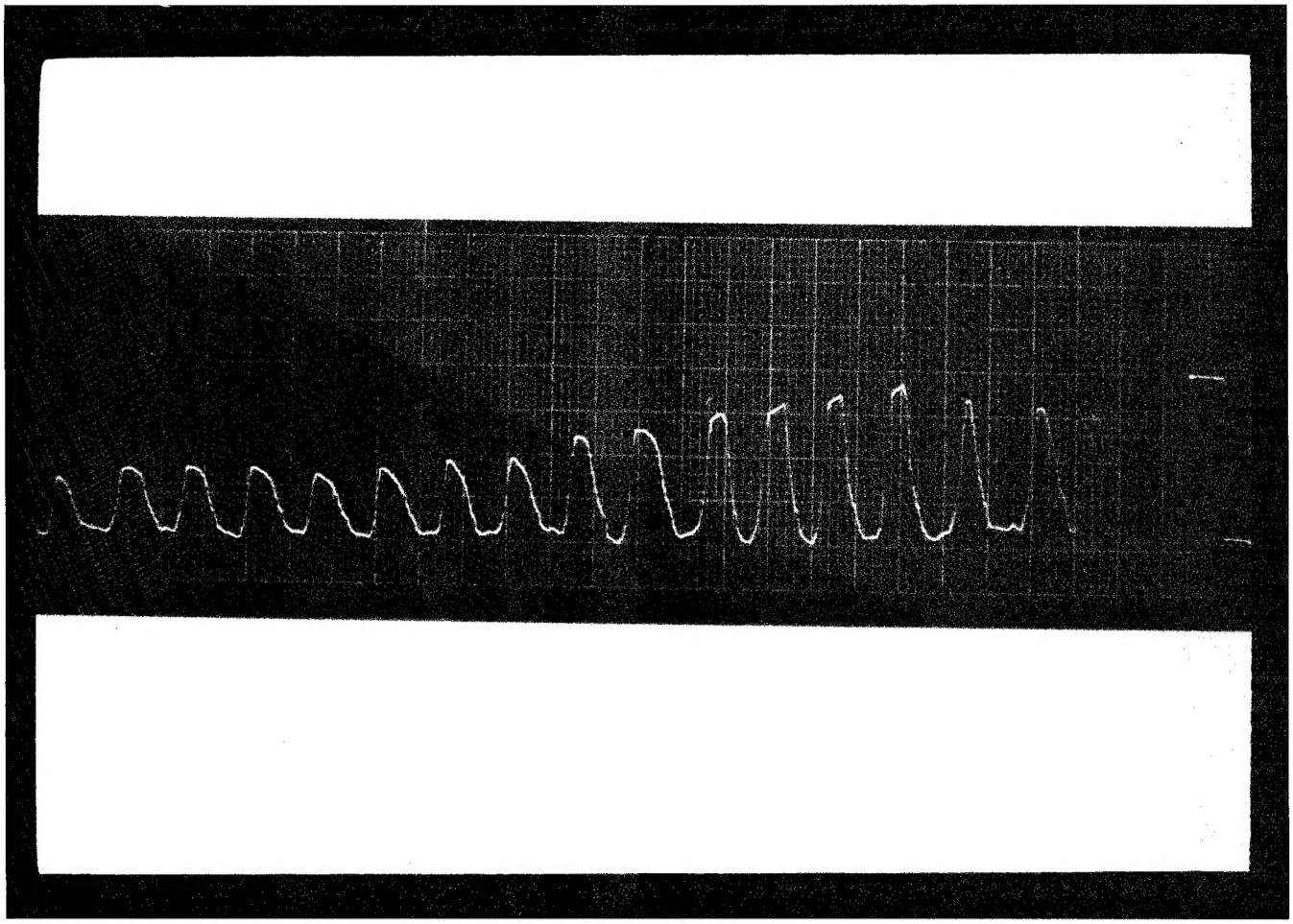


FIGURE 8: Continuation of tracing in Fig. 8. The large and rapid fluctuations in IOP are the result of digital message of the globe.



Publications:

Cavallaro, B., Ward, T., Peele, K., Hollifield, R.,Wertz, F., Closure of Scleral Lacerations with Cyanoacrylate Adhesive. Investigative Ophthalmology and Visual Science. 1992; 33(4):abstract 3095.

CLOSURE OF SCLERAL LACERATIONS WITH CYANOACRYLATE ADHESIVE. Brian F. Cavallaro, Thomas P. Ward, Kimberly A. Peele, Rodney D. Hollifield, and F. Denton Wertz, III. Walter Reed Army Medical Center, Washington, DC
Ocular injuries are expected to comprise up to 10% of total casualties on the modern battlefield and would overwhelm the limited medical facilities available near front lines. An expedient method of stabilizing open eyes is needed. Our study was designed to evaluate the efficacy of cyanoacrylate adhesive (CA) in the temporary closure of scleral lacerations. A 6 mm laceration was created 3 mm posterior to the limbus in albino rabbits. The animals were randomized into three groups: standard closure with sutures (13), closure with CA (18), or untreated (16). The animals were evaluated by clinical exam, intraocular pressure (IOP), and bright-flash electroretinogram (ERG) prior to both wound placement and enucleation. The animals were euthanized at 2 days, 1, 2, 4, and 8 weeks. On histopathologic examination, a fibrous bridge was noted in all animals by 2 weeks. Prior to fibrous bridge formation, IOP's and dark-adapted ERG a- and b-wave amplitudes were significantly lower in open eyes compared to those in which wounds were surgically closed using CA or suture.

	OPEN	CA	SUTURED	
IOP (mmHg)	0.0 ± 0.0	7.8 ± 2.5	13.0 ± 3.0	*P=0.0440
a-wave (mV)	30.9 ± 9.9	72.5 ± 9.0	89.6 ± 8.7	*P=0.0146
b-wave (mV)	69.3 ± 26.7	179.6 ± 21.2	193.4 ± 14.2	*P=0.0182

*Using Kuskal-Wallis One-way ANOVA; mean ± SEM

A trend toward delayed wound closure was noted on histopathologic analysis of the glued eyes examined within the first 2 weeks. Otherwise, the clinical course of the CA group compared favorably with eyes closed by the standard suture technique. This study supports the efficacy of using cyanoacrylate adhesive as a temporary, battlefield expedient method of closing scleral lacerations.